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MECHANICALLY LOCKABLE UNIVERSAL JOINT AND STRUCTURES EMPLOYING SUCH JOINT

RELATED APPLICATION

This application claims priority of United States Provisional Patent Application Serial No. 60/461,921 filed April 10, 2003, which is incorporated herein by reference.

FIELD OF THE INVENTION

This invention relates to a mechanical joint for securing two structural elements in any of a wide variety of positional relationships, to a unique lock for such joints, and to structures employing such joints.

BACKGROUND OF THE INVENTION

A wide variety of mechanical devices employ universally adjustable joints for connecting two elements at a variety of positional relationships. For example, in optical apparatus it is often necessary to support an element, such as a camera or a laser, in a unique position relative to other elements and to be able to lock the joints which support the element to ensure maintenance of a chosen positional relationship. Similar jointed stands are often used in supporting medical apparatus, vehicle components, etc.

Often these supports include two or more elongated links or arms joined by universal joints so that the arms may be arrayed in any chosen relation with respect to

one another. By way of example, U.S. Patent 6,168,126 discloses a multi-adjustable stand for vehicle electronic components including a pair of arms and adjustable, lockable joints for securing the arms in any variety of positions relative to one another. U.S. Patent 6,220,556 discloses a similar system for supporting switches above a base.

SUMMARY OF THE INVENTION

The present invention is directed to such universal joints and to adjustable support structures employing said joints. In a preferred embodiment of the invention, which will subsequently be disclosed in detail, each joint takes the form of a pair of complementary knuckles. Each knuckle is adapted to be supported at one end of an elongated strut or rod by means of a splined connection with the strut. The knuckle preferably employs a cylindrical member at one of its ends which is splined and fixed within a splined hole at the end of the strut. Alternatively, this relationship may be reversed with a splined cylinder extending from the end of the strut and joining in a female splined hole in the knuckle. These splined joints allow the rotational position of the knuckles relative to the links to be adjusted. A locking mechanism may secure the splined joint after adjustment.

The end of each knuckle which extends outwardly from the strut to which it is connected includes a splined hole extending generally perpendicularly to the rod axis. A pair of knuckles connected to two links may be joined by means of a splined pin which extends through both of the holes in the two knuckles. This allows the two

knuckles to be adjusted about the rotational axis of the pin. Thus, three axes of adjustment are provided for the joint. The two splined connections which join the knuckles to the rod ends may each be individually rotationally adjusted, and the position of the two knuckles relative to one another may be similarly adjusted about an axis generally normal to the two rods or links.

Preferably, the female splines formed in a pair of complementary knuckles have different numbers of spline teeth to maximize the number of rotational orientations possible. It is advantageous if the two numbers of splines do not have a common denominator. For example, one spline may have thirty teeth and the other spline may have nineteen teeth. This allows 30 x 19 different rotational positions or a .6 degree rotational adjustment between the two knuckles.

The splined pin which joins the two knuckles has two splined sections of different diameter formed on its barrel and the splined holes formed in the two knuckles are of different diameter. The section of the splined pin adjacent to the head end is of larger diameter and the extending cylindrical section is of smaller diameter. When the pin is inserted into the knuckles to lock the two complementary knuckle sections into locking relationship, the smaller diameter section is passed through the knuckle with the larger diameter hole so that the extending section of the pin clears the splines and the extending section is then inserted into the smaller diameter splined hole in the second knuckle section so that the splines on the extending section of the pin engage the internal splines on the hole in the second knuckle. The larger diameter

section of the pin adjacent to the head then engages the splines in the first knuckle section. The extending section is formed with splines complementary to the internal splines formed in the second section, and the larger diameter section on the pin is formed with splines complementary to the first knuckle section. In the example given the section adjacent to the head of the pin has a thirty-tooth spline and the extending section, of smaller diameter, has a nineteen-tooth spline. This allows the two knuckle sections to be rotationally adjusted relative to one another to a .6 degree rotational resolution.

In order to lock the two knuckles relative to one other, the knuckles preferably each have flat faces which are brought into mating contact with one another when the spline connection between the knuckles is locked. In order to achieve this lock, the hole in which the spline is formed on one of the complementary knuckles will be made at a slight angle, preferably around 1 degree, to perpendicular of the mating faces. In that way, when the knuckles are assembled by the pin there will be a slight angle between the mating surfaces. The far end of the pin has a threaded central hole and a bolt may be inserted into the hole to force the splines outwardly and lock the knuckles in their selected positional relationship. This locking force pushes the two flat mating faces of the complementary knuckle sections into contact with one another and forces the splines on the pin to preload removing any slack in the joint resulting from manufacturing tolerances.

In an alternative embodiment of the invention the knuckles may be joined to their supporting links by splined cylinders which extend from the ends of the links and fit into mating splined holes in the knuckle. In this form, the knuckle essentially consists of an L-shaped bracket with two splined holes, one in each face of the bracket.

The support stands formed using these universal joints may employ a flat base member which may be secured to a supporting surface so that the stand extends generally normally to that surface. The link at the other end of the support stand may employ a universal joint which secures the supported apparatus such as a camera or laser.

Other objects, advantages and applications of the present invention will be made apparent by the following detailed description of preferred embodiments of the invention. The description makes reference to the accompanying drawings in which:

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an exploded perspective view of a support stand for a camera employing three elongated links joined by universal joints;

Figure 2 is a detailed perspective view of one of the universal joints in exploded form;

Figure 3 is a cross-sectional view, in exploded form, of one of the universal joints; and

Figure 4 is an exploded view of an alternative form of the joints wherein the knuckles simply consist of L-shaped elements having splined apertures in each face.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

A preferred embodiment of the invention is illustrated in exploded form in Figure 1. This embodiment is employed to support a camera 10 in a selected position above a supporting surface. It should be understood that a wide variety of other devices which must be securely supported and aligned may be used with the stand. The stand preferably employs three links 12, 14 and 16, formed by tubes, preferably steel, aluminum or composite material. One end of the tubular link 12 is secured to a base member 18 which may be weighted, or attached to a supporting surface by fasteners so that the tubular link 12 extends generally vertically to the supporting surface, although, in alternative embodiments the support surface need not be horizontal and the supported link may extend at any angle to the support surface.

The upper end of the tubular link 12 is joined to one end of the second tubular link 14 by a splined universal joint, generally indicated at 20, while the opposite end of the second tubular link 14 is connected to one end of the third tubular link 16 by an identical universal joint generally indicated at 22. A similar universal joint, generally indicated at 24, secures the opposite end of the third tubular link 16 to the camera 10. In practice, the splined universal joints could be used to form a stand with one or more links.

A detailed view of the splined universal joints 20 and 22 is illustrated in Figure 2. The joint illustrated joins the tubular link 12 to the tubular link 14. The joint 22 is identical and the joint 24 is very similar. The joined ends of the linked tubes 12 and 14 terminate in identical end caps 26. The end caps include a small diameter cylindrical section 28 having an outer diameter which makes a press fit with the internal diameter of the tube and is secured in the tube 12 by welding or the like. A shoulder 30 joins the section 28 to a larger diameter end section 32 and bears against the end of its associated tube. The end caps 26 have central splined holes which receive the splines 34 of a knuckle 36a or a complementary knuckle 36b. A locking pin 38 extending through a threaded hole in the end cap 26 secures the spline member 34 in a unique position. This spline connection provides a first axis of rotational adjustment for the support stand.

The spline 34 is formed in a unitary manner, or alternatively securely joined, with an end section 40 of the knuckle 36a which has a central splined internal hole with its axis extending generally normally, or at a slight angle to the normal, to the axis of the splined section 34.

A complementary knuckle 36b is adjustably supported in the end cap 26 at the end of the tube 14 and the two units 40 are secured together by a splined pin 42 which passes through splined holes in both of the members 40. This mechanism provides a second axis of adjustment and the rotational position of the member 40 within the end cap 26 of the tube 14 provides a third axis of adjustment.

In a preferred embodiment of the invention the splined pin has a central threaded hole. A screw 44 passing through a washer 46 may be inserted into the central hole of the pin 42 to axially spread the pin and lock the exterior splines of the pin 42 to the interior splines in the two members 40.

Referring to Figure 3, the knuckled joint is illustrated in exploded cross section and in more detail. In this view the components of the lower knuckle section are denominated with the suffix "a" and the components of the upper knuckle section are denoted with the suffix "b". The end cap 26a has a central splined aperture 29a formed with a thirty-tooth spline to receive the thirty-tooth spline on the knuckle member 34a. Similarly, the internal aperture 29b of the end cap 26b has a nineteen-tooth internal spline to accommodate the nineteen-tooth spline on the knuckle section 34b. These spline selections, or alternative spline selections in which the two splines do not have a common denominator, allows adjustment of the rotational position of the strut 12 relative to the strut 14 with a resolution of at least .6 degrees.

The knuckle section 36a has a central splined hole 37a which is of slightly larger diameter than a similar splined hole 37b formed in the knuckle section 36b. The pin 42 has a head 44 and a splined cylinder 46 of relatively large diameter arranged immediately adjacent to the head. Beyond the section 46 a smaller diameter section 48 projects. Pin section 48 has a central threaded hole adapted to receive a threaded bolt 50 for locking purposes. The section 46 has a spline count of thirty as does the larger hole 37a in the knuckle 36a. The smaller diameter section 48 has a

spline count of nineteen as does the internal spline formed in the section 37b of the knuckle 36b.

The joint is locked by passing the pin 42 first through the spline section 37a so that the larger diameter section of the pin 46 engages that spline, and the smaller diameter end section of the pin 48 engages the splined hole 37b in the knuckle section 36b. The difference in the number of splines in the two knuckles allows the two knuckles to be angularly adjusted with respect to one another within a resolution of .6 degrees.

The splined hole 29a in the end cap 26a is preferably formed at a one-half degree angle to the center line of the upper face of the end cap as is the hole 29b in the end cap 26b. Similarly, the two splined holes 37a and 37b on the two knuckle sections are each offset by a half degree with respect to the center line. The joint is locked together by screwing the bolt 50 into the tapped end of the pin 42. This forces the two flat faces 41a and 41b of the two knuckle sections into locking engagement and loads the pin to lock the entire universal joint in fixed position.

Figure 4 illustrates an alternative form of the invention wherein two knuckle sections 60a and 60b simply comprise L-shaped brackets with central splined holes. The bracket 60a has a splined hole 62a in one of its faces and a splined hole 64a in its other face. The aperture 62a preferably has a thirty-tooth spline as does the aperture 64a. The two apertures are formed with an 89 degree included angle between their center lines.

Similarly, the knuckle section 60b is formed with two splined apertures 62b and 64b in its two arms. There is preferably a 91 degree included angle between the center lines of these two apertures. Both of the apertures are preferably formed with a nineteen-tooth spline.

A locking pin, generally indicated at 66, has a head 68, a large diameter thirty-tooth splined cylindrical section 70 adjacent the head, and an extending, smaller diameter nineteen-tooth spline section 72. The section 72 is formed with a central threaded aperture (not shown) which can be locked in with the bolt 74 and a washer.

The joint of Figure 4 secures a strut 76, supported on a base 78 and having an extended splined cylinder 80 to a second strut 82 which has a cylindrical splined end extending section 84. The spline 80 preferably has thirty teeth and the spline 84 has nineteen teeth. The universal joint of Figure 4 is locked by passing the pin 66 through the spline section 62a so that the larger diameter spline section 70 in the pin engages the interior spline section 62a. Then the extending section 72 of the pin is locked to the interior splined hole 62b. The spline cylinder 80 attached to the strut 76 is adjusted within the splined aperture 64a and the cylindrical spline section 84 is adjusted within the aperture 64b.

A threaded bolt 74 and washer are then engaged in the threaded aperture in the end of the pin to force the two opposing faces 86a and 86b of the two knuckles into intimate engagement. This loads the pin and the two splined cylinders 80 and 84

because of the offsets between their center lines, removing all tolerances from the universal joint.

The supports and stands formed in accordance with the present invention are useful in situations where flexibility and adjustability are necessary at the time of the installation but, once the proper position is attained, the support must stay at the exact location for the duration of the application.

The present invention eliminates the possibility of readjustment of the stand without extensive use of tools.

One skilled in the art should understand that the stand or support could take many forms involving one or more links and one or more universal joints. Having thus described my invention I claim: